# Development and Characterization of a Children's Beverage Using By-Products from the Dairy Industry

Ayna Arora[1*], Alba Mayta-Apaza[1], Joana Ortega-Anaya[1], and Rafael Jimenez-Flores[1]

[1]Department of Food Science and Technology, The Ohio State University, 2015 Fyffe Ct., Columbus, OH 43210

*arora.163@osu.edu

**Abstract**

The study aims to develop a children's beverage repurposing 2 dairy by products: acid whey from cottage cheese production and buttermilk powder (BMP). This beverage will serve as a healthier alternative to products that provide little nutrition. The by-products being used have high nutritive value as they contain protein and milk phospholipids. However, their undesirable flavors yield in no significant use in the dairy industry. Through this beverage, they can be used in a potentially profitable manner. The aim is achieved by improving the organoleptic properties of the by-products by comparing four processing treatments to increase palatability. The acid whey is processed, diluted to 10% solids, and mixed with BMP to achieve formulations with 12% total solids. Treatments included rotary evaporation (RV), ultrafiltration (UF) with a 10kD molecular weight cutoff, centrifugal evaporation (SV), and a combination of UF followed by SV. 9 Panelists evaluated BMP samples to determine the treatment with most acceptable organoleptic properties, and also compared it to formulations with 12% total solids with skim milk powder (SMP), as a point of reference. Treatments were ranked from 1-4, with 4 being most preferred and 1 being least preferred. The pH of the samples ranged between 4.1-4.6, causing precipitation of the SMP, and hence panelists preferred the texture of BMP samples. UF and combination treatment were rated the highest, with average ratings of 3.11 and 2.89 respectively, whereas RV was rated the lowest at 1.89. Of all analyses, only protein for UF and UF+SV were significantly different compared to untreated acid whey. UF increased the concentration of fat by 0.05% (highest of the four) and protein by 1% compared to untreated acid whey. As UF is the highest rated and is a technology that can be readily scaled up, it will be used to further develop the beverage.

## Introduction

An estimated 8.4 billion pounds of acid whey are produced each year (Hamilton, 2015) having undesirable flavors no feasible use. The flavor is often described as “cheese water” like and has posed a barrier to using acid whey as an ingredient.

Buttermilk powder is a by-product that is made during the butter making process- the fat from cream separates from the continuous phase, yielding buttermilk. It is high in protein (33%) (Sodini, Olabi, and Jimenez-Flores, 2006) with 4 times as much phospholipids as whole milk (Christie, Noble and Davies, 1987) shown to have anticarcinogenic potential (Dillehay, Schmelz and Merill, 1994) .

By treating the whey using physical methods to improve organoleptic properties and combining with buttermilk powder, a nutritious beverage can be formulated. This will be a sustainable use of resources while allowing consumers to have a novel yogurt-type drink to supplement their daily activities. The beverage is targeted towards children to provide them a better, more nutritive option in the categories they most consume- milk beverages and fruit juices (Fulgoni and Quann, 2012). Most new beverage innovations are targeted towards adults, leaving ample room for innovation in the children’s sector. By incorporating tropical flavors such as passionfruit or pineapple, children can not only be exposed to newer fruits earlier on, but the product can also create lifelong customers by targeting them early.

**Table 1.** Composition of buttermilk and acid whey.

| Characteristic | Acid Whey from Cottage Cheese | Buttermilk Powder[1] |
|---|---|---|
| **%Solids** | 8.59 | 96 |
| **%Fat** | 0.07 | 4.5 |
| **%Protein** | 1.02 | 30 |
| **pH (at 4°C)** | 4.37 | - |

[1] Dairy America, 2013

## Objectives

The study aims to develop a children's beverage using 2 dairy by products: **acid whey** from cottage cheese and **buttermilk powder**, as a nutritious alternative. The study focuses on the physical processing methods best suited for improving the organoleptic properties of acid whey and determining the effect of buttermilk powder addition from an organoleptic perspective.

## Methods

*Acid Whey Treatment*

The acid whey was treated in 4 different ways. Treatment one was rotary evaporation (Rotavapor R-210 and Vacuum Controller V-855, Buchi, New Castle, DE) that was processed at 80mbar and 42C to achieve a 33% volume reduction. Treatment two used centrifugal evaporation (Genevac EZ-2 Plus Evaporating System, Genevac, Ipswich, United Kingdom) processed acid whey at 3mbar at 35C for 2.5 hours yielding a 12% volume reduction. Treatment three used ultrafiltration (Masterflex I/P Easy-Load Pump Head, Masterflex, Gelsenkirchen, Germany; Millipore Pellicon 3 0.57$m^2$ Cassete, Millipore, Darmstadt, Germany) with a 10kD molecular weight cutoff membrane. The sample at 4C was run through the filter at 30psi to obtain a 50% volume reduction, and the retentate was used for the beverage formulation. Treatment four was a combination of 2 treatments- first, the acid whey was processed with membrane filtration, followed by centrifugal evaporation.

*Characterization*

After each type of treatment, the acid whey was characterized. For analytical methods, % solids (SMART 6™ Moisture and Solids Analyzer, CEM Holdings Corporation, Matthews, NC) and % fat (SMART Trac Fat Analyzer, CEM Holdings Corporation, Matthews, NC) was measured. Additionally, % protein (Sprint Rapid Protein Analysis, CEM Holdings Corporation, Matthews, NC) and pH were also measured (S220 SevenCompact™ Benchtop pH/ISE Meter, Mettler Toledo, Columbus, OH).

*Base Preparation and Sensory Analysis*

The bases were diluted with water to a 10% or less total solids (depending on the % solids concentration after processing). For sensory comparison, either buttermilk powder or skim milk powder was added to each of the treatment samples to obtain 12% total solids. The samples were heated to 70C and held at that temperature for 1min to pasteurize. Following cooling of samples, 9 panelists evaluated the buttermilk samples amongst themselves and the skim milk samples amongst themselves, ranking it from 1-4: 4 being like the most and 1 being like the least. They were further asked to select an overall preference of skim milk or buttermilk.

**Results and Discussion**

The characterization of different treatments of acid whey were analyzed using T tests. The following abbreviations hold for the figures: Acid Whey- AW; Rotary Evaporation- RV; Centrifugal Evaporation- SV; Ultrafiltration- UF; Ultrafiltration followed by Centrifugal Evaporation- UF+SV.

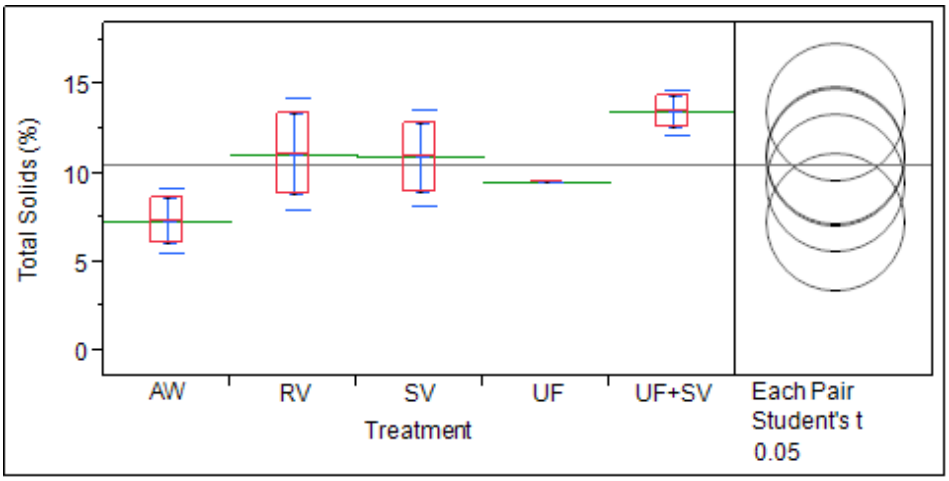


**Figure 1.** % solids of different treatments of acid whey.

While there was no significant difference in % solids of the treatments compared to untreated acid whey, some increase in % solids was observed for all treatments- the highest being for ultrafiltration followed by centrifugal evaporation. All except ultrafiltration use some kind of heating process, and hence only lose water and volatiles. However, for ultrafiltration, given the membrane size, some of the lactose, calcium, and acid is lost in the permeate. As for the samples that used centrifugal evaporation, there was sedimentation of particles that were difficult to resuspend uniformly without homogenization; this can result in inaccurate readings for solids, fat, and protein.

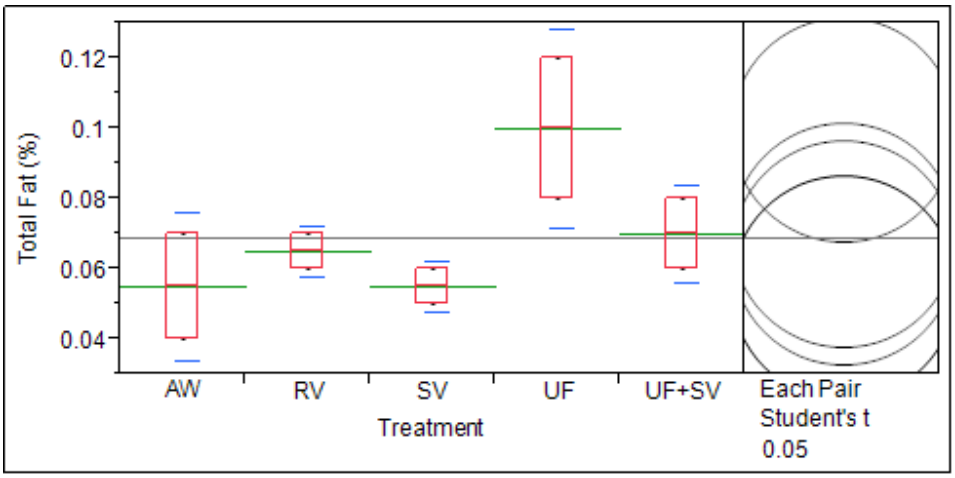


**Figure 2.** % fat of different treatments of acid whey.

While fat was not significantly different for any of the samples, the ultrafiltration method correspondingly doubles the concentration of fat, which could potentially contribute to an improved mouthfeel.

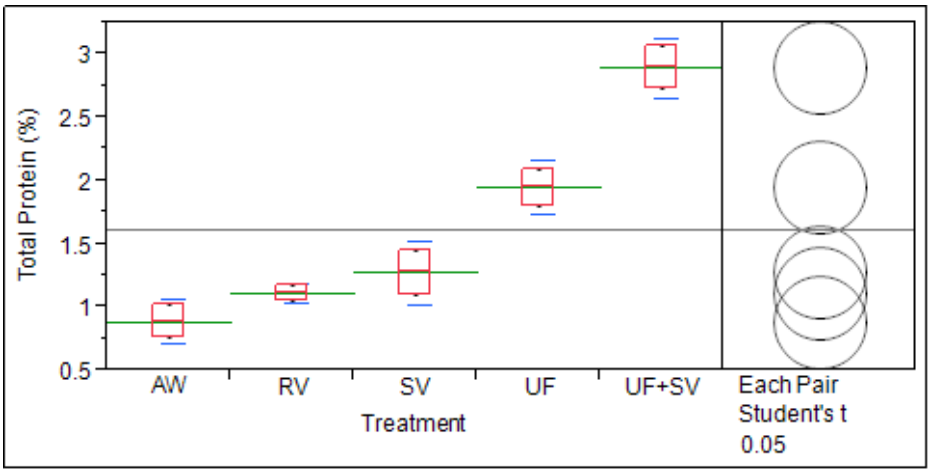


**Figure 3.** % protein of different treatments of acid whey.

The ultrafiltration and ultrafiltration followed by centrifugal evaporation were found to be significantly different in % protein compared to untreated acid whey (1.7% and 2.7% respectively for the treatments). This is certainly desirable from a nutritional view point.

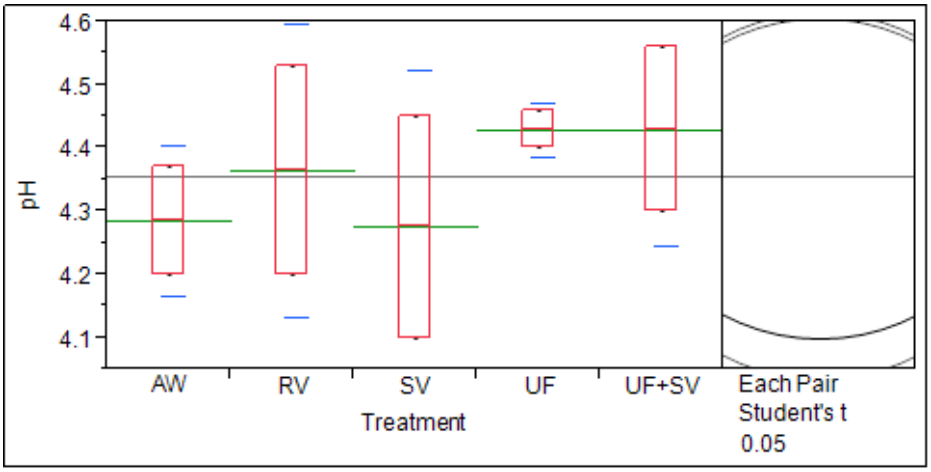


**Figure 4.** pH of different treatments of acid whey.

The pH had high variability and there was no significant difference between any of the treatments compared to untreated acid whey. However, the mean pH of ultrafiltration and ultrafiltration followed by centrifugal evaporation is somewhat higher compared to untreated acid whey (both 4.45). This is desirable as a beverage with a very low pH would not only precipitate the proteins, but also be too acidic from an organoleptic standpoint.

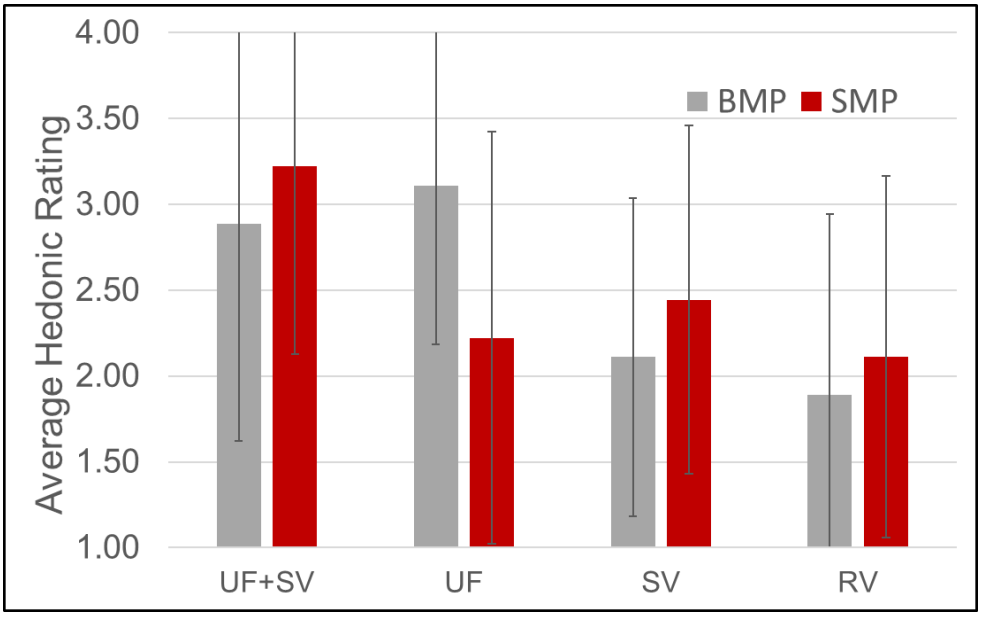


**Figure 5**. Average raking of buttermilk powder (BMP) and skim milk powder (SMP).

9 panelists were asked to evaluate the samples. While not a significant number, they can help inform the direction of the study. Overall, the panelists preferred the sweetness of the skim milk and the texture of the buttermilk. Milk tends to have a sweeter taste which was shown to be a desirable property for the final beverage. However, skim milk also coagulated forming cottage-cheese like curds in the formula, which was rated as an off-putting texture. While the buttermilk did precipitate to some extent, the suspension was more palatable in terms of texture. The panelists rated 4 formulations with one type of powder on a scale of 1-4, with 4 being like the most and 1 being like the least. The ultrafiltration was the highest rated, followed by centrifugal evaporation. This could be due to increased fat and protein with a slightly higher pH compared to the other treatments. Rotary evaporation was the least effective, potentially due to high processing temperature yielding a slightly "cooked" flavor, and no removal of off flavors and acid. The two step process of ultrafiltration followed by centrifugal evaporation received the second highest rating, potentially due to the sedimentation of the particles that require homogenization.

**Conclusions**

The ultrafiltration treatment was shown to have highest consumer acceptability, with a texture preference of buttermilk powder over skim milk powder and a preference for product with less acidity and increased sweetness. The ultrafiltration method will be investigated further given its scale up potential in the industry, and diafiltration will additionally be experimented with. The beverage will be mixed with fruit purees with inherently acidic flavor profiles, such as passionfruit and pineapple to yield a flavorful and nutritious beverage. Further, homogenization and stabilizers will be added to the process to help create a more stable and palatable beverage.

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